DATA REQUIREMENTS
FOR MODELING THE
SEABORNE MOBILE
LOGISTIC SYSTEM

TASK 72-7

May 1972

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LOGISTICS MANAGEMENT INSTITUTE
4701 Sangamore Road
Washington, D. C. 20016

PREFACE

This is the final report on LMI Task 72-7, "Data
Requirements for Modeling the Seaborne Mobile Logistic System
(SMLS)." The SMLS is a concept of amphibious operations under
study by the U.S. Navy and Marine Corps. The concept calls for
greatly increased logistic support of a Marine amphibious
operation from a seabase rather than from a base ashore.

Essential to the SMLS study effort has been the
development of a computer simulation model which will permit
experimentation and testing of alternate concepts and designs
prior to expensive field trials. In order to test and evaluate
system concepts, adequate and relevant data of sufficient
quality must be available for input to the model. This report
addresses the quantity and quality of available data suitable
to the SMLS model.

A great deal of cooperation and assistance, primarily from
personnel in the Department of Defense, was required throughout
this survey. We gratefully acknowledge their assistance.

SUMMARY

The purpose of this task was to review the quantity and quality of available data suitable to the Seaborne Mobile Logistic System (SMLS) simulation model. Data requirements were specified for the logistic functions of medical, supply, transportation, and maintenance. The level of detail required by the SMLS model demanded that the data be representative of company and battalion level activity on a minute-by-minute basis.

There has been a general lack of success in identifying data sources for the model. Although some data were found for weight and cube requirements and for medical casualty rates, data voids exist for equipment failure rates, repair times, communication times, processing times at communication nodes, and for determination of critical medical casualties.

Because of the absence of ample data, it is recommended that provisions be made for sensitivity analyses. Such analyses would show the effect of variations in input data. Sensitivity analyses should be used to pinpoint those aspects of SMLS which should be subjected to thorough field testing or for which it is advisable to obtain more detailed data. As a result of sensitivity analyses, more accurate or detailed data may prove necessary. When such is the case, field trips, data collection schemes, or special tests may be required to obtain historical data or to gather sample data.

13. ABSTRACT

This report presents the results of a review of the quantity and
quality of available input data suitable to the Seaborne Mobile Logis-
tic System (SMLS) simulation model. Data requirements were specified
for the logistic functions of medical, supply, transportation and
maintenance. The level of detail required by the model demanded that
the data be representative of company and battalion level activity on
a minute-by-minute basis. There has been a general lack of success in
identifying data sources for the model. Although some data were found
for weight and cube requirements and for medical casualty rates, many
data voids still exist. Because of the absence of ample and adequate
data, the report recommends that provisions be made for sensitivity
analyses. Such analyses would show the effect of variations in input
data. As a result of sensitivity analyses, more accurate or detailed
data may prove necessary. When such is the case, field trips, data
collection schemes, or special tests may be required to obtain his-
torical data or to gather sample data.

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I. INTRODUCTION

A. PURPOSE

This report presents the results of work under LMI Task 72-7, "Data Requirements for Modeling the Seaborne Mobile Logistic System (SMLS)," dated 13 August 1971. The original purpose of the task was to "assist the Navy/Marine Corps Amphibious Forces Study Group by working with the Seaborne Mobile Logistic System Technical Director and the Naval Ship Research and Development Center (NSRDC) in determining modeling requirements."[1] However, following task order approval, the Headquarters, Marine Corps and the Office of the Chief of Naval Operations restructured the SMLS study organization. As a result of the restructuring, the focus of LMI's effort was shifted toward an emphasis on identifying and evaluating data sources for the model to be used in the SMLS simulation. During the period of restructuring the study organization, LMI work essentially was suspended. Therefore, the original completion date of 31 December 1971, called out in the Task Order, was revised to 28 April 1972.

B. SCOPE

The Navy Amphibious Warfare Board and the Marine Corps Development and Education Command (MCDEC) function as the SMLS study's executing agencies for their respective Services. Management of the study effort is under direction of the Study Technical Director at MCDEC.

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[1]Task Order 72-7 appears in Appendix 1.

The SMLS will provide logistic support of a Marine Amphibious Brigade (MAB) or Unit (MAU) from a seabase rather than from a base ashore. Essential to the study effort has been the development of a computer simulation model. A suitable model will permit experimentation and testing of alternate concepts and designs of the SMLS prior to expensive field trials. The analysis under this task order consisted of a survey of potential data sources in order to determine the quality and quantity of available data.

C. BACKGROUND

The SMLS is a combination of ships, forces, and doctrine designed to provide logistic support of combat operations. As presently conceived, SMLS relieves combat units of the burden of carrying ashore their required logistic support. It is based on the consolidation of service support functions; on a flexible responsive transportation system; and on a logistics command and control system. The logistic support organization remains aboard the ships of the amphibious seabase, making maximum use of shipboard facilities. Maintenance, medical facilities, and supply support remain aboard ships of the seabase. Combat units ashore receive their major support directly via helicopter and surface transport from the seabase, with such support controlled and coordinated by a Logistics Support Center located afloat.

The model was developed by the Naval Ship Research and Development Center, Carderock, Maryland, under the guidance of the Technical Director of the SMLS Study; see, e.g., Joseph J. Fuller and Paul Hubai, Development, Operating Procedures, and Capabilities of the NSRDC Computer Simulation Model for the First-Generation Seaborne Mobile Logistics System (SMLS) Concept, U.S. Department of the Navy, Naval Ship Research and Development Center Technical Note No. CMD-33-71 (Washington: U.S. Government Printing Office, August 1971).

A significant amount of time would be required for field evaluation of the system. Such tests are costly and are restricted by the availability of facilities. Moreover, field tests may not be good test media because knowledge of the precise sequences of actions and interactions necessary for quantitative evaluation are not yet available.

Therefore, a method was needed which would enable preliminary testing and evaluation of SMLS. A simulation model was chosen as the analytic tool which would best serve this purpose.

The SMLS simulation model is organized by logistic subsystem as follows:

- maintenance (motor transport, ordnance, electronics, aviation, engineering, and general support)

- supply

- medical/dental

- transportation

- logistics command and control

The model has the capabilities to:

- test SMLS policies and procedures

- study the interaction of subsystems

- test modifications and revise subsystem parameters and evaluate the effects of such changes

- evaluate alternative system configurations

Simulated exercises can be generated on the computer to investigate selected aspects of SMLS procedures. Techniques and procedures within each logistic subsystem can be varied. Illustrative variations include number and type of communications networks, mix of supply inventory on supply ships, configuration changes in maintenance facilities, number of maintenance personnel, type and mix of helicopters, etc. The simulated exercises, with variants, are based on company-level activity on a minute-by-minute basis.

The Naval Ship Research and Development Center selected the TRANSIM methodology as best suited to the SMLS modeling requirement.[1] TRANSIM permits the subsystems (e.g., medical, supply, transportation, maintenance) to be analyzed individually or as parts of the total system, taking into account the system interrelationships and interactions. System procedures, facilities, equipments, and designs may be varied in order to evaluate the effects of such changes.

TRANSIM is composed of a standard computer program and a set of input data which define a specific problem. The two components of TRANSIM needed to define the system are traffic units and system operating elements. Typical traffic units are helicopters, messages, supplies, equipments, etc., which move through the system. Operating elements are ships, helicopter pads, command centers, etc., through which the traffic units flow. TRANSIM can simulate the actual movement, servicing, delay, and routing of traffic units among operating elements without development of special mathematical relationships.

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[1] TRANSIM--General Purpose Transportation System Simulator--Users' Manual, University of California, Los Angeles, Report 66-6, May 1966.

A significant level of detail is required of the data used by the model. Data requirements include, for example, the mean time between failure for each item of supported equipment in the SMLS, as well as the variance, or the frequency distribution. As another example, the probability of the occurrence of a medical casualty during any period of a day for small size combat units also must be known. The data requirements of the model, as identified by the NSRDC, are listed in Appendix 2.

D. APPROACH

As a preliminary phase, several reviews were conducted prior to undertaking the major portion of the task. The first of the reviews concerned reports of field tests and exercises for SMLS. That review provided background for the remainder of the task.

Secondly, a review of selected logistic publications was conducted. Publications documenting logistic support in SEA were reviewed primarily for references to possible data sources and not for the data per se. Other publications reviewed include such subjects as logistic planning guides and procedural directives dealing with existing logistics information systems.

Another review concerned existing analyses of SMLS. This review was intended to provide estimates of critical capacities, that is, elements of the SMLS which might prove limiting in the system. Data and modeling of such elements would have to be in sufficient detail and accuracy to permit thorough design and testing of alternative concepts regarding such elements. This aspect was not completed because of the study restructuring.

The major emphasis of this task was a review of available input data. The review was conducted primarily through discussions with personnel knowledgeable in relevant areas throughout the Department of Defense and industry, with an emphasis on contacts in the Department of the Army. Appendix 3 lists those contacts.

II. SURVEY OF POTENTIAL DATA SOURCES

A. INTRODUCTION

The search for data sources began with agencies in the metropolitan Washington area. By identifying local sources and by taking advantage of the ability of headquarters personnel to identify potential key sources in the field, unnecessary field trips were avoided.

When potential field sources were identified, exploratory telephone calls were made to verify and identify the most promising source within any one organization. This was particularly appropriate for larger field activities. Field trips to agencies were made only when there was a response indicating availability of substantial and relevant data.

It was indicated early in the task that Marine Corps records contained little specifically suitable data. Therefore, the search focused on Army agencies because of the prevalence of similar ground equipment and combat structure.

There has been a general lack of success in the search for data sources. Apparently field data usually are collected with relatively few purposes in mind. Data sources invariably seem to have collected the data in categories and level of detail which preclude use in the SMLS model. For example, data on medical casualty rates mostly are based on division level strengths and actions of several days duration. There are few data on this subject for smaller units. Such situations are

prevalent for all of the data requirements of SMLS. Hence, the data sources identified for all of the logistic subsystems are quite few in number.

Although the data requirements, contained in Appendix 2, are listed separately for each subsystem, many of the data elements are used in several of the subsystems. Those requirements have been grouped for ease of exposition. Data availability for these groupings is discussed in paragraph B. Each data element, unique to a subsystem, is addressed separately by subsystem in paragraph C.

B. DATA REQUIREMENTS COMMON TO SEVERAL SUBSYSTEMS

The data requirements addressed in this section are those which, by their nature, are common to several subsystems of the SMLS model. For example, there is a time associated with the transmission of a message, be that message medical, supply, transportation, or maintenance. Although the length of time for transmission may differ according to the length and complexity of the message, means of transmission, skill of the communicator, etc., the subject matter of the message is not relevant. Hence, communication transmission times are grouped so that they may be addressed at one time in this report. Several other data elements can also be grouped generically and addressed in the same manner as follows:

1. Communication Transmission Times

No source of data has been identified for data elements in this category.

2. Processing Times

No source of data has been identified for the various processing times.

3.   Weight and Cube Data

Requirements for this classification of data fall into three categories: (a) vehicles and outsize equipments, (b) supplies and minor equipments, and (c) personnel.   For the first category, the best known source is the Continental Army Command (CONARC) Movement Planning and Status System (COMPASS). This file is maintained on magnetic tape at CONARC and can be accessed by federal stock number (FSN).   However, for weight and cube data on just one or two hundred items of vehicles and outsize equipments likely in SMLS, a more practical approach would be to research the hard copy of the file.   That document is entitled "Standard Characteristics (Dimensions, Weight, and Cube) for Transportability of Military Vehicles and Equipment," TB 55-46-2, Headquarters, Department of the Army, dated 28 July 1971.

In the second case, i.e., supplies and minor equipment, the best source of weight and cube data is the Army Master Data File (AMDF).   The packaging segment of the AMDF contains weights and cubes for nearly one million federal stock numbers.[1]   This file is maintained by the U.S. Army Materiel

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[1] Care must be exercised when obtaining weight and cube data for supply items.   Characteristics of packaging must be taken into account when such dimensional data are sought.   For example, a vacuum tube may be packed in a thin cardboard carton or it may have been overpacked in a larger package with cushioning material for subsequent trans-oceanic shipment.   Hence, knowledge of weight and cube for a given item may be meaningless without knowledge of its level of pack.   The AMDF is appropriately coded in reference to the various forms of packaging prescribed in MIL-STD-726.

Also, it must be known whether the weight and cube data are oriented to the unit of issue or the unit of pack.   Army regulations require its inventory managers to orient weight and cube to unit of pack.   However, DSA and GSA weight and cube

Command Catalog Data Office, New Cumberland Army Depot, New Cumberland, Pennsylvania. Permission to query AMDF must be obtained from the U.S. Army Materiel Command (AMCDT-E), Cataloging and Data Management Office, Distribution and Transportation Directorate, Washington, D. C.

Weight and cube data for personnel are needed for the medical subsystem and for the maintenance subsystem. These weights and cubes should be based on tables of average height and weight of individuals. Such information is available from the Medical Statistics Agency, Office of the Surgeon General, Department of the Army.[1] They have collected and analyzed data on the enlistees and inductees for all of the military services who have passed through the Armed Forces Examining and Entrance Stations. The data are recent, having been collected during August 1969 to January 1970; however, the age group is restricted to personnel of ages 17-26. Heights are given as a function of race and age in 2-year intervals. Weights are given as a function of height, race, and age, also in 2-year intervals. The measures of variability of the data are also available.[2]

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data, in nearly all cases, are oriented to unit of issue. As of 1 January 1972, approximately 61% of the FSN's in the packaging record of the AMDF with weight and cube data available are DSA and GSA managed items. Hence, those items have weight and cube data oriented to the unit of issue.

[1] The results are unpublished since the work is still in progress under the supervision of Dr. John Vinyard.

[2] Another source of height and weight data is the Army Materiel Command, Natick Laboratory, Natick, Massachusetts. Anthropometric data have been analyzed for seventy different body measurements taken from 2000 Marine Corps personnel. Although these data strictly represent Marine Corps personnel, the Natick Laboratory states that there is no statistical

4. <u>Helicopter Load and Unload Times</u>

No sources have been identified for these data requirements.

5. <u>Miscellaneous: Circuit Noise</u>[1]

No sources have been identified which could provide data upon which a distribution of circuit noise could be based.

Other than weight and cube data, no sources have been identified for any other data requirements common to several subsystems.

C. <u>DATA REQUIREMENTS UNIQUE TO A SUBSYSTEM</u>

In addition to those generic groupings common to several subsystems, there are data requirements which are unique to an individual subsystem. These requirements are addressed, for the most part, in the same order in which the data elements appear in Appendix 2.

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significance in the differences between heights and weights of Marines and those same measurements for Army personnel. The Marine Corps height and weight data are in tabular form and include the mean, standard deviation, range, and coefficient of variance. Although the data represent a young age group, the data per se were collected in 1966. The results of the analysis, performed by Mr. Robert M. White, will not be published until the Fall, 1972. However, the data are available now by contacting Major Jaime Sabater, Jr., USMC, the Marine Corps Liaison Officer at the Natick Laboratory.

[1] The information passed over communication circuits can be divided into two categories. One is SMLS logistic information. The second category contains all other messages being passed over the circuits. It includes messages such as clarification of a prior transmission, status of a request, etc. This group as a whole is termed circuit noise.

1. Medical Subsystem

The medical subsystem requires the following unique inputs:

- frequency of occurrence of medical requests

- probabilistic load units per request[1]

- probabilistic determination of casualty receiving ship

These unique inputs to the medical subsystem are discussed below.

a. Frequency of Occurrence of Medical Requests (1.1)[2]

The detailed frequency of occurrence of medical requests cannot be obtained directly from available data. There is a time lag associated with the occurrence of a casualty and the formal request for medical attention. In a situation where casualties are tallied on a day-by-day basis, there is no apparent need to relate medical requests to periods of time less than a day. This is not the case in SMLS simulations which require a high resolution of time. Hence, the distinction between the occurrence of casualties and the occurrence of medical requests is appropriate to SMLS.

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[1] Probabilistic load units refer to the number of casualties per medical request.

[2] The number 1.1 refers to the first data element of the first subsystem (i.e., medical), as contained in Appendix 2. Subsequent references to data elements in the medical subsystem are assigned the numbers 1.2, 1.3, etc. Correspondingly, the data elements of the remaining subsystems are numbered 2._, 3._, and 4._, respectively for the supply, transportation, and maintenance subsystems.

There are no data available to permit estimation
of the length and variability of that time lag. Such a time
lag can be influenced by factors such as the intensity of com-
bat, the dispersal of combatants, the proximity and capability
of front-line communications, deployment of medics, initial
diagnosis of the severity of the wound, terrain, weather, etc.

The impact of those factors can be measured by
manipulating the model. Such manipulation would, of course,
depend upon both the parameters and assumptions introduced by
those doctrinal, environmental, scenario-related, and physical
factors noted above. It is reasonable to assume that the
frequency of occurrence of medical requests is dependent, not
only upon this time lag, but also upon the frequency of
occurrence of medical casualties.

On that basis, an analysis of selected medical
casualty data was performed by LMI. The analysis, contained in
Appendix 4, comprises a discussion of medical evacuation (MEDEVAC)
requirements, a discussion of casualty rates, a procedure for
generating a random daily casualty rate, a Monte Carlo tech-
nique for generating casualty occurrences, and a discussion of
the impact of the tactical and environmental factors influencing
the choice of a suitable daily probability distribution for the
SMLS simulation model. In part, our study concludes that the
daily casualty rate is exponentially distributed. However,
such a conclusion says nothing about the distribution of casu-
alties throughout a given day. No data are available on the
distribution of casualties within a day. At this point, impor-
tant explicit assumptions must be made in order to postulate a
distribution of the frequency of occurrence of casualties over
intervals of time shorter than one day. The assumptions to be

made must address the scope and intensity of the combat operations to be simulated as well as the tactical doctrine employed. This can best be determined by professional military experience. Factors influencing these assumptions are discussed in Section F of Appendix 4.

b. Probabilistic Load Units per Request[1] (1.2)

Here, as with the discussion of data requirements in subparagraph a. above, a distinction must be made between the number of casualties included in any one medical request versus the number of casualties which occur during any one casualty-producing event. In the case of the former, the number will be highly dependent upon the timeliness of the reporting (as discussed earlier), a possible opportunity to consolidate individual requests at each hierarchical level in the reporting structure, etc. as well as the multiple number of casualties which may have occurred. There are no data available which would permit a direct estimation of the number of casualties per medical request. Much depends on circumstances as well as reporting doctrine and reporting methodology.

However, in an instantaneous reporting environment, the number of casualties per medical request would be identical to the number of casualties which might occur at any given moment in time. Since there are no data available for casualty rates for intervals of time shorter than a day, then determination of casualty load units directly from available data is not possible. But, the simultaneous occurrence of multiple casualties can be simulated. Section E of Appendix 4

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[1]Probabilistic load units refer to the number of casualties per medical request.

contains a technique for the realistic generation of multiple casualties. As before, the assumptions to be made must be explicit and acceptable to professional military judgment. Discussion of the impact of factors influencing such assumptions is contained in Appendix 4.

      c.   Probabilistic Determination of Casualty Receiving Ship (1.3)

          No sources of data have been identified which could provide a means for making this determination. The determination of casualty receiving ship appears to be highly dependent upon scenario selection. Factors such as number of available beds and other facilities, sizes and skill levels of the respective medical teams, distances from ships to combat areas, capabilities of the ships to receive MEDEVAC helicopters at any given moment, etc., are the influencing factors in the determination of the casualty receiving ship.

    2.   Supply Subsystem

          The supply subsystem requires the following unique inputs:

      a.   Frequency of Occurrence of Supply Requests (2.1)

          A review of a sample of after-action reports of Marine Corps combat engagements in RVN indicates that some reports contain relevant raw data. The data could be extracted and used to develop crude frequency distributions. However, the extraction process would be time consuming and validity of the data would be degraded by the low quality of the estimates included in the after-action reports. Therefore, it is believed that the field experience of Marine officers would be a more practical data source at present. Sensitivity analysis should establish the need for later refinements.

b.   Probabilistic Load Units per Supply
Request[1] (2.7)

No data sources have been identified for this
input requirement. Daily usage rates from current planning
documents could be applied for many classes of supply.
Requirements for Class IX material can be obtained from the
Replacement Factor File at the Marine Corps Supply Activity,
Philadelphia. Requirements for Classes II and IV would have to
be estimated from field experience.

The shortest time interval addressed by any
known planning document is a one-day period. No source has
been identified which specifies supply requirements for shorter
time periods. Hence, without such data, logic dictates that
the frequency of supply issues on a "pull" basis should result
from actions in the combat scenario. Quantities of supplies
requested for any one scenario-activated occurrence could be
derived from military judgment. In any case the average total
quantity requested in a day should be approximately equal to
the daily rate for appropriate classes of supply.

c.   Inventory Level at Supply Ships; Level of
Inventory at which Supply Ships will Request
Replenishment; Amount of Supplies in a
Replenishment; and, Time to Replenish (2.10
thru 2.13)

The requirement for LMI to identify sources for
these data elements was deleted by the SMLS Study Panel.

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[1]Probabilistic load units refer to the number of units of
issue per request. The unit of issue is a specified minimum
for each type of supply.

d.   Time to Break Out Supplies, etc. (2.14)

The only source identified for this data element is the output from the model, developed by Presearch, Incorporated, which simulates cargo movement on the LKA 113.[1] However, the times calculated have not been verified with actual data since so little real data are available. Moreover, the times may not represent the load-out doctrine for SMLS.

e.   Probabilistic Determination that when a Routine Supply Request will not be Filled, the Unit will Cancel the Routine Request and Submit an Emergency Request (2.19)

No source of data has been identified.

3.   Transportation Subsystem (3.1 thru 3.4)

The requirement for LMI to seek data inputs (e.g., flight times, refueling times, and helicopter capacities) to the transportation subsystem was deleted by the SMLS Study Panel. The Panel believed reliable data were in hand.

4.   Maintenance Subsystem

The maintenance subsystem requires the following unique inputs:

a.   Frequency of Occurrence of Maintenance Requests (4.1)

This is comparable to a frequency distribution of mean-time-between-failure (MTBF) for all equipments in SMLS. Efforts to find suitable field data for MTBF for SMLS

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[1] Work on the model is in process under contract with the Department of the Navy: Naval Ship Systems Command (Code 03412B) and the Office of Naval Research (Code 643), Washington, D. C.

equipments indicate that there is very little available. One potential data source, the U.S. Army Logistics Data Center, Lexington, Kentucky, has gathered maintenance data for several hundred equipments. However, only nine of these equipments are to be used in SMLS.[1]

Design and performance specifications were sampled for maintenance parameters. The review identified few data concerning MTBF which are applicable to SMLS equipments. Additionally, according to our contacts, the limited data found bore little relation to field experience.

b. Probabilistic Determinations[2]

No available data have been identified which would permit computation or estimation of these probabilities.[3]

c. Time Restraints on Contact Teams (4.6); Length of Mandatory Rest for Contact Teams; Shop Hours; and, Length of Rest and Clean-up Time for Contact Team Arriving from the Field (4.8 thru 4.10)

No source of data has been identified for these data elements. Moreover, it seems that the elements depend on doctrine and systems design rather than historical experience.

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[1] Appendix 5 contains a list of the nine equipments.

[2] Here, "probabilistic determinations" refer to decision points in the maintenance management process, e.g., whether to support or reverse a shop supervisor's recommendation to embark a maintenance casualty for shipboard repair.

[3] Comments here refer to data availability for "probabilistic determinations" throughout the maintenance subsystem.

d.   <u>Repair Time Distribution[1] (4.11)</u>

Except for the field data used by the Logistics Data Center to compute the mean-time-to-repair (MTTR) for nine SMLS equipments, no sources have been identified.

e.   <u>Diagnosis Time Distribution[1] (4.12)</u>

No source identified.

f.   <u>Whether Loaded Inside the Helicopter or Carried Externally (4.20)</u>

This determination can be made given the weight, dimensions, and volume of the cargo/passengers and size of the cargo hatch and the capacity of the helicopter. This is not an input data element, but rather, it is dependent upon the state of the system, e.g., whether the helicopter is scheduled for other loads and the dimensions of those loads.

g.   <u>Time to Move from Storage and Prepare for Helicopter Pick-up on Ship; and, Time to Move Maintenance Casualties from Helicopter Deck to Maintenance Shop Queue (4.22 and 4.23)</u>

The only source identified for these data elements is the Presearch, Incorporated simulation model.

h.   <u>Time to Prepare Equipment for Helicopter Pick-up from Unit to Seabase (4.24)</u>

No source of data has been identified for this requirement.

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[1] Distributions referred to here are cumulative probability distributions, i.e., the probability that an event will take at least a specified time.

i. Float Levels (4.25)

Computation of this requirement can be made if MTBF, MTTR, and mission availability are known. Since data for MTBF and MTTR are not readily available, quantitative determination of these requirements must be left to the judgment of experienced Marine officers.

III. CONCLUSIONS

There are very few sources of readily available data
applicable to the SMLS simulation model. Data voids exist for
equipment failure rates, repair times, communication times,
processing times at communication nodes, and for determination
of critical medical casualties. Where sensitivity analyses
show more accurate or detailed data are necessary, field trips,
data collection schemes, or special tests may be required to
obtain historical data, or to gather sample data.

A. DATA REQUIREMENTS COMMON TO SEVERAL SUBSYSTEMS

1. Communication Transmission Times; Processing Times; and Helicopter Load and Unload Times

These times can be obtained by experimentation where
sensitivity and other analyses indicate the need.

2. Weights and Cubes

The data sources identified herein are the best known
sources. There is no reason to expect that these data sources
can be improved upon; nor is there any apparent need for
additional sources of weight and cube data.

B. DATA REQUIREMENTS UNIQUE TO A SUBSYSTEM

1. Medical

No suitable data were found which would indicate
casualty distribution rates except for the Marine Corps
Operations Analysis Group (MCOAG) analysis of Special Landing

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Force operations in RVN and the MCDEC Medical/Dental Study.[1]
These studies appear to be the best known sources which are
relevant and applicable to the SMLS study. It is recognized
that certain explicit assumptions must be made in order to
utilize these data to derive daily rates and associated distrib-
utions. However, there is no reason to believe that data of the
fine-grain detail required are readily available elsewhere.

2. Supply

No applicable data sources were identified. It is
suggested that standard planning factors be employed. The fre-
quency of occurrence of supply requests could be aligned with
the combat scenario. Total quantities requested throughout the
day, plus quantities pushed during the simulation, should
approximate the daily usage rates found in planning guides.

3. Maintenance

The need for data to support failure rates and repair
times is apparent. Thorough, detailed review of equipment
records and log books of forces in the field could yield the
raw data necessary to permit computation of the appropriate
statistics. This approach is suggested because there appears to
be no reason to expect that such data are readily available any-
where else. Some data have been provided to the SMLS Study
Panel;[2] however, their validity is open to question. It is
suggested that service test data not be utilized because
statistical correlation of such data with field data has not
been performed.

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[1] A discussion of these studies is contained in Appendix 4.

[2] MTBF, MTTR, and measures of maintainability had been
provided for the equipments listed in Appendix 5.

C. SENSITIVITY ANALYSIS

Because of the nature of the available data, as well as the absence of much data, provision must be made for sensitivity analyses. Such analyses would show the effect of variations in input data. Sensitivity analyses should be used to pinpoint those aspects of SMLS which should be subjected to thorough field testing or for which it is advisable to obtain more detailed data.

APPENDIX 1

LMI TASK ORDER 72-7

APPENDIX 1

ASSISTANT SECRETARY OF DEFENSE
Washington, D. C.

Installations and Logistics   DATE: 13 AUG 1971

TASK ORDER SD-271-163
        (TASK 72-7)

1.   Pursuant to Articles I and III of the Department of
Defense Contract No. SD-271 with the Logistics Management
Institute, the Institute is requested to undertake the follow-
ing task:

A.   TITLE: Data Requirements for Modeling the
                      Seaborne Mobile Logistic System (SMLS)

B.   SCOPE OF WORK: LMI will assist the Navy/Marine
Corps Amphibious Forces Study Group by working with the SMLS
Technical Director and the Naval Ship Research and Development
Center in determining SMLS modeling requirements.   The analysis
will consist of:

1) Review of reports of previous field
   tests and exercises,

2) Review of available input data, and

3) Review of existing analyses.

These steps will be used to determine:

1) Quality and quantity of available data,

2) What modeling restrictions data availa-
   bility implies, and

3) What additional and improved data are
   essential.

2.   SCHEDULE: A final report will be submitted by 31 December
1971.

APPROVED___/s/ Hugh Witt_____

                                  ___/s/ Glenn V. Gibson_____

ACCEPTED___/s/ William F. Finan___

DATE_____16 AUG 1971_____

APPENDIX 2

LIST OF DATA REQUIREMENTS

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LIST OF DATA REQUIREMENTS

This appendix contains a list of input data requirements for the SMLS model. This list is extracted from enclosure (2) of a memorandum from Head, Amphibious Warfare Group, Naval Ship Research and Development Center, to Technical Director, Seaborne Mobile Logistics System (SMLS), MCDEC dated 28 October 1971.

This appendix is divided into five sections. The first four contain the data elements required for each of the SMLS subsystems:

- medical

- supply

- transportation

- maintenance

The last section contains miscellaneous data requirements.

Each data element in each section is identified by a set of numbers: the first defining the applicable section, the second identifying the data element within the section. This unique identifier is used throughout the text in order to facilitate reference to the specific data elements in this appendix.

The purpose of including this list is to identify the specific results of the data survey for each of the requested input elements. Notes and page numbers used in this appendix refer to appropriate discussion in the main body of the report.

ABBREVIATIONS AND ACRONYMS

BNHQ   – Battalion Headquarters

BNLOG   – A communications radio net called Battalion
             Logistic Net

FLCC   – Forward Logistic Control Center

HRNET   – A communications radio net called Helicopter
             Regulating Net

LKA   – Amphibious Cargo Ship

LOGCMD   – A communications radio net called Logistic
             Command Net

LPH   – Amphibious Assault Ship

LSC   – Logistic Support Center

MSBCOM   – A communications radio net called
             Mobile Seabase Common Net

SLCC   – Ships Logistic Control Center

TACNET   – A communications radio net called Battalion
             Tactical Net

1. MEDICAL SUBSYSTEM

Data Elements	Notes
1.1 Frequency of occurrence of medical requests (by unit, by priority, by type).	See p. 12(a)
1.2 Probabilistic load units per request (by priority).	See p. 14(b)
1.3 Probabilistic determination of casualty receiving ship (LPH or LKA).	See p. 15(c)
1.4 Processing time for medical request at unit level (by priority).	See p. 8(B2)
1.5 Weight and volume units per casualty.	See p. 9(B3)
1.6 Transmission time on TACNET for medical transportation request (by priority).	See p. 8(B1)
1.7 Processing time at BNHQ for a medical transportation request (by priority).	See p. 8(B2)
1.8 Transmission time on HRNET for a medical transportation request (by priority).	See p. 8(B1)
1.9 Transmission time on BNLOG for a medical transportation request (by priority).	See p. 8(B1)
1.10 Processing time at FLCC for a medical transportation request (by priority).	See p. 8(B2)
1.11 Transmission time on LOGCMD for a medical transportation request (by priority).	See p. 8(B1)
1.12 Processing time at LSC for a medical transportation request (by priority).	See p. 8(B2)
1.13 Time to load MEDEVACS onto helo (by type).	See p. 11(B4)
1.14 Time to unload MEDEVACS from helo (by type).	See p. 11(B4)

2. SUPPLY SUBSYSTEM

Data Elements	Notes
2.1 Frequency of occurrence of supply requests (by unit, by priority, by type, internal or external delivery).	See p. 15 (a)
2.2 Processing time at unit level for supply requests (by priority).	See p. 8 (B2)
2.3 Transmission time on BNLOG for supply requests (by priority).	See p. 8 (B1)
2.4 Processing time at FLCC for supply request (by priority).	See p. 8 (B2)
2.5 Transmission time on LOGCMD for supply requests (by priority).	See p. 8 (B1)
2.6 Processing time at LSC for supply requests (by priority).	See p. 8 (B2)
2.7 Probabilistic load units per supply request (by priority, by type).	See p. 16 (b)
2.8 Transmission time on MSBCOM for supply requests (by priority).	See p. 8 (B1)
2.9 Processing time at SLCC for supply requests (by priority).	See p. 8 (B2)
2.10 Inventory level at supply ship(s) (by type).	See p. 16 (c)
2.11 Level of inventory at which supply ships will request replenishment (by type).	See p. 16 (c)
2.12 Amount of supplies in a replenishment (by type).	See p. 16 (c)
2.13 Time to replenish (by type).	See p. 16 (c)
2.14 Time to break out supplies, make ready for delivery, and move to helo deck (by type, by priority).	See p. 17 (d)
2.15 Weight and volume units of supplies (by type).	See p. 9 (B3)
2.16 Time on MSBCOM for supply transportation request (by priority).	See p. 8 (B1)

2. SUPPLY SUBSYSTEM (Continued)

Data Elements	Notes
2.17 Helo load time for supply shipment (internal or external, by type, by priority).	See p. 11(B4)
2.18 Helo unload time for supply shipment (by type, internal or external, by priority).	See p. 11(B4)
2.19 Probabilistic determination that when a routine supply request will not be filled, the unit will cancel the routine request and submit an emergency request.	See p. 17(e)

3. TRANSPORTATION SUBSYSTEM

Data Elements	Notes
3.1 Time required to refuel helo (by type).	Deleted, See p. 17
3.2 Time for helo to fly 5, 10, 15, 20, 25, 30, ..., 50 nautical miles (a) empty (b) internal load (c) external load (by type)	Deleted, See p. 17
3.3 Flight time of fully fueled helo (by type).	Deleted, See p. 17
3.4 Weight and volume capacities of empty helo (by type).	Deleted, See p. 17

4. MAINTENANCE SUBSYSTEM

Data Elements	Notes
4.1 Frequency of occurrence of maintenance requests (by unit, by priority, by type).	See p. 17(a)
4.2 Probabilistic determination of shop supervisor's recommendation (send contact team or embark maintenance casualty for shipboard repair) (by priority, by type).	See p. 18(b)
4.3 Probabilistic determination of whether LSC Maintenance Coordinator will support or reverse the shop supervisor's recommendation (by recommendation, by priority, by type).	See p. 18(b)
4.4 Probabilistic determination of whether LSC Maintenance Coordinator would elect to send an available float item to replace a routine maintenance item which is being embarked to the seabase for shipboard repair (by type).	See p. 18(b)

4.5   Probabilistic determination
 	
    i) to repair
 	
   ii) to recommend embarkation of
 	
  iii) to request parts, test equipment and/or special tools for maintenance casualty in the field by a contact team after diagnosis
 	
(by type, by priority)
	See p. 18(b)

4.6 Time restraints on contact teams (e.g., cannot remain in the field over night) (by contact team type).	See p. 18(c)
4.7 Probabilistic determination of whether LSC Maintenance Coordinator will have contact team await parts or reassigned given i) there are not time restraints such that the contact team should return to the seabase	See p. 18(b)

4. MAINTENANCE SUBSYSTEM (Continued)

Data Elements	Notes
ii) there is no emergency casualty of the proper type at the same unit	
iii) there is at least one maintenance casualty of the proper type in the contact team queue	
(by contact team type, by casualty type, by priority).	
4.8 Length of mandatory rest for contact team (by type).	See p. 18(c)
4.9 Shop hours (by type).[1]	See p. 18(c)
4.10 Length of rest and clean-up time for contact team arriving from field (by type).	See p. 18(c)
4.11 Repair time distribution	See p. 19(d)
(a) at seabase	
(b) in field	
(by type).	
4.12 Diagnosis time distributions	See p. 19(e)
(a) at seabase	
(b) in field	
(by type, by priority).	
4.13 Transmission time of each of the following types of maintenance messages on BNLOG and LOGCMD	See p. 8(B1)
(a) maintenance requests	
(b) prepare maintenance casualty for embark	
(c) no replacement sent--cannot repair	

---

[1] Capacities of each maintenance shop in terms of man-hours available

4. MAINTENANCE SUBSYSTEM (Continued)

Data Elements	Notes
(d) contact team orders from unit to unit or to seabase	
(e) contact team availability	
(f) recommendation to embark maintenance casualty (from contact team)	
(g) parts/equipment request	
(h) parts/equipment arrived--need contact team	
(by type, by priority).	
4.14 Transmission time of each of the following types of maintenance messages on MSBCOM	See p. 8 (B1)
(a) maintenance requests	
(b) shop supervisor's recommendation	
(c) no replacement--cannot repair	
(d) contact team orders from seabase to unit level	
(e) contact team availability	
(f) prepare parts/equipment for delivery to unit	
(g) prepare float item for delivery to unit	
(by type, by priority).	
4.15 Transmission time of each of the following transportation requests on BNLOG and LOGCMD	See p. 8 (B1)
(a) maintenance casualty from unit to seabase	
(b) contact team from unit to unit or to seabase	
(by type, by priority).	

4.   MAINTENANCE SUBSYSTEM (Continued)

Data Elements	Notes
4.16 Transmission time of each of the following transportation requests on MSBCOM (a) repaired maintenance casualty from seabase to unit (b) contact team to unit (c) float item to unit (d) parts/equipment to unit (by type, by priority).	See p. 8 (B1)
4.17 Processing times of each of the message types in 13 and 15 at the unit level, at the FLCC and at the LSC.	See p. 8 (B2)
4.18 Processing time of each of the message types in 14 and 16 at the SLCC and at the LSC.	See p. 8 (B2)
4.19 Time to load and time to unload (a) maintenance casualties (b) float items (c) parts/equipment (d) contact teams (by internal-external, by priority, by type).	See p. 11 (B4)
4.20 Whether loaded internally or externally (by type).	See p. 19 (f)
4.21 Weight and volume units of (a) maintenance casualties (b) float items (c) parts/equipment (d) contact teams (by type).	See p. 9 (B3)

4. MAINTENANCE SUBSYSTEM (Continued)

Data Elements	Notes
4.22 Time to move from storage and prepare for helo pick-up on ship	See p. 19(g)
(a) repaired maintenance casualties	
(b) float items	
(c) parts/equipment	
(by type).	
4.23 Time to move from helicopter deck to shop queue maintenance casualties (by type).	See p. 19(g)
4.24 Time to prepare for transport from unit to seabase	See p. 19(h)
(a) maintenance casualties	
(b) contact teams	
(by type, by priority, by unit).	
4.25 Float levels (by type).	See p. 20(i)

5. MISCELLANEOUS

Data Elements	Notes
5.1 Noise on nets	See p. 11(B5)
(a) BNLOG	
(b) LOGCMD	
(c) MSBCOM	
(d) TACNET	
(e) HRNE"	

APPENDIX 3

LIST OF OFFICES, AGENCIES, AND FIRMS CONTACTED

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LIST OF OFFICES, AGENCIES, AND FIRMS CONTACTED

Department of the Army:

Army Maintenance Board

Army Materiel Command

Army Materiel Command Catalog Data Office

Combat Developments Command Headquarters

Combat Developments Command (Maintenance Agency)

Combat Developments Command (Medical Agency)

Combat Developments Command (Supply Agency)

Combat Developments Command (Systems Analysis Field Office)

Electronics Command

Headquarters, Department of the Army

Logistic Doctrine, Systems, & Readiness Agency

Logistics Data Center

Major Item Data Agency

Natick Laboratory

Office of the Surgeon General

Tank & Automotive Command

Test & Evaluation Command

Walter Reed Army Institute of Research

Weapons Command

Department of the Navy:

Bureau of Medicine & Surgery

Marine Corps Supply Activity

Naval Communications Command

Naval Medical Data Services Center

LIST OF OFFICES, AGENCIES, AND FIRMS CONTACTED (Continued)

      Naval Ship Systems Command

      U.S. Marine Corps Headquarters

Other Organizations:

      Center for Naval Analysis (Marine Corps Operations Analysis Group)

      Control Systems Research

      Defense Supply Agency

      Presearch, Incorporated

      Research Analysis Corporation

      Stanford Research Institute

APPENDIX 4

ANALYSIS OF SELECTED MEDICAL CASUALTY DATA

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APPENDIX 4

ANALYSIS OF SELECTED MEDICAL CASUALTY DATA

A. INTRODUCTION

This appendix presents the results of LMI research and analysis of relevant medical casualty data. The SMLS model requires data on occurrences of casualties at battalion le _ and below, on a minute-by-minute basis, throughout the day. While a number of sources in the literature discuss casualty rates, those rates are either aggregated on a monthly basis or else by battles, regardless of length of time. The rates found in those same sources also apply to a variety of combat elements, from company to army size. Daily casualty rates for company and battalion level combat units are occasionally available in such form as after-action reports, but their reliability concerning time of occurrence, as well as type of casualty, must be considered with caution. The stresses of combat are not conducive to accurate record-keeping on a minute-by-minute basis. Thus, considerable analysis was necessary to develop the probabilistic occurrence of casualties throughout a day.

Specifically, this appendix contains a discussion of medical evacuation requirements, a discussion of casualty rates, a procedure for generating a random daily casualty rate, and a Monte Carlo technique for generating casualty occurrences based on tactical doctrine and battlefield environment. The appendix concludes with a discussion of the impact of the tactical and environmental factors influencing the choice of a suitable daily probability distribution for the SMLS simulation model.

B. **MEDICAL EVACUATION (MEDEVAC) REQUIREMENTS**

Battle casualties are categorized as follows:[1]

- **Killed in action** (KIA) - resulting in immediate death, or dying before treatment at a medical facility; caused by enemy action.

- **Wounded in action** (WIA) - caused by enemy action, not resulting in death before treatment at a medical facility.

- **Died of wounds** (DOW) - caused by enemy act. n. and resulting in death after treatment at medical facility; included in WIA.

- **Missing in action** (MIA) - lost to enemy action from unknown causes; may include those captured, interned, or on unauthorized absence.

- **Disease and non-battle injury** (DNBI) - losses not attributable to enemy action; includes both fatalities and non-fatalities.

The categories of interest to SMLS studies and simulations are WIA's and DNBI's requiring evacuation (WIAE's and I :3IE's) and KIA's, which, of course, also require evacuation. There are several references which discuss WIA's, DNBI's, and KIA's

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[1]The definitions of KIA, WIA, DOW, and MIA are found in U.S., Department of Defense, Headquarters, Department of the Army, *Army Medical Service Planning Guide*, Field Manual No. 8-55, 23 October 1960, pp. 127-28. This reference does not contain a definition of DNBI. The DNBI definition is consistent with usage in supporting source documents for U.S., Department of Defense, Department of the Navy, Commandant of the Marine Corps Project No. 90-69-03, *Medical and Dental Support Concept for Fleet Marine Forces-Mid-Range (U)*, Marine Corps Development and Education Command secret letter, serial 0046CQ0472, dated 4 January 1972.

as fractions of total casualties. FM 8-55[1] describes the KIA's as representing about 17% of total casualties from World War II and Korean War experience. That fraction is confirmed in FM 101-10-1[2] and may be used as an estimator for KIA's. FM 8-55 describes wounded or injured in action casualties as representing about 70% of total casualties from the same experience. That fraction is also confirmed in FM 101-10-1 and Summers,[3] and may be used as an estimator for WIA's and DNBI's. However, that estimator is not accurate for determination of casualty evacuation requirements.

It is then necessary to categorize separately WIAE's and DNBIE's for such determination. For the most part, WIA rates given in the literature do not make this distinction. Wilder[4] discusses briefly the categorization of frequency of battle injuries into critical, non-critical, and not evacuated. No other available references provide that information specifically. Those frequencies (14.5%, 80.1%, and 5.4%) should be viewed with caution, particularly in the case of combat elements smaller than a division. With such units, it

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[1] Field Manual No. 8-55, Army Medical Service Planning Guide, loc. cit., p. 154.

[2] U.S., Department of Defense, Headquarters, Department of the Army, Organizational, Technical, and Logistical Data, Field Manual No. 101-10-1, 26 July 1971.

[3] Summers, Wallen M., Combat Casualties and Mission Accomplishment, U.S. Army Command and General Staff College, March 1970, AD 713-373.

[4] Wilder, Hubert B., Jr., Systems Analysis of the Seaborne Mobile Logistics System Concept, 1975-85, Stanford Research Institute, Menlo Park, California, May 1969, AD 867-203, p. 88.

is more appropriate to seek histories of recent combat involving elements of comparable size and mission. Summaries of after-action reports generally make the distinction between evacuated and non-evacuated WIA's and DNBI's. These should be consulted for appropriate frequencies.

C. DAILY CASUALTY RATES FOUND IN THE LITERATURE

In arriving at reliable estimates of casualty distributions it would be desirable to refer to studies which examine the manpower and firepower of both sides, climate, topography and defensive fortifications. HERO[1] has made the only study of recent combat which satisfies those criteria. That report discusses at length the difficulties in obtaining data with any degree of reliability, even for allied forces. The data base includes 37 major battles at divisional level and above: 9 battles in Italy, WWII; 2 battles in France, WWII; 15 battles in Okinawa, WWII; and 11 battles of the Korean War. The results included estimates of casualties on both sides for each battle, and the duration of battle.

Best[2] discusses allied losses in various campaigns of World War II and the Korean War, including rifle-company level casualty rates. FM 8-55 and FM 101-10-1 also describe casualty experience of U.S. forces in World War II and the Korean War. Summers provides a selective example of casualties incurred at the company level in Italy, WWII. Those results are shown in Table 4-1, listing extremes and mean casualty rates.

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[1] Historical Evaluation and Research Organization, "Average Casualty Rates for War Games, Based on Historical Combat Data," McLean, Virginia, 15 February 1967.

[2] Best, Robert J., Casualties and the Dynamics of Combat (U), McLean, Virginia, Research Analysis Corporation, Technical Paper #185, Confidential, March 1966, AD 372-260.

TABLE 4-1

CASUALTY RATES FROM SELECTED HISTORICAL DATA

Source	Combat Element Level	Type of Casualty Rate	Casualty Rate (%)		
			Lower	Mean	Upper
Best	Rifle Company	Total Battle Losses/Company Casualty Day* (European Theater of Operations)	2.10	3.10	4.10
Best	Rifle Company	Total Battle Losses/Company Casualty Day (Mediterranean Theater of Operations)	.52	2.45	4.60
Best	Rifle Company	Total Battle Losses/Company Calendar Day* (European Theater of Operations)	.12	.86	2.00
Best	Rifle Company	Total Battle Losses/Company Calendar Day	0.00	.53	1.15
FM 8-55	Division	Wounded in Action/Day:			
		Beachhead Operations	.28	1.10	3.22
		Offensive Breakthrough	.59	.72	.95
		Assault on Fortified Lines	.34	.51	1.42
		Defensive Operations	.16	.37	1.50
FM 101-10-1	Division	Wounded in Action/Day	.02	--	.14
Summers	Company	Wounded in Action/Day	0.00	3.80	25.50
HERO	Division	Total Battle Losses/Day:			
		Attacker	.12	.96	19.30
		Defender	.24	7.90	44.20

*Company calendar day is a day in nominal conflict with the enemy. Company casualty day is a calendar day in which at least one casualty is incurred.

Only the HERO and Summers data in Table 4-1 provide any means of estimating the distribution of casualties. The HERO data indicate for each of the 37 battles the number of days the battle endured and the casualty rate per day for both attacker and defender. This casualty rate is averaged over the entire period of the battle; hence, it does not indicate the variation in casualty rates on a day-by-day basis.

Despite this lack of fine-grain data, further analysis suggested that a daily casualty distribution can be inferred using only the averaged casualty rates available from the literature. The objective of this analysis was to determine if the data followed the form of a classical distribution. In this regard, the analysis focused on the frequency of occurrence of casualty rates, i.e., the number of days on which the recorded casualty rates were incurred. With that in mind, the HERO data were transformed to the cumulative frequency chart in Figure 4-1; for convenience, a logarithmic scale was employed

FIGURE 4-1
CUMULATIVE FREQUENCY
OF DAILY CASUALTY RATE
HERO DATA

DAILY CASUALTY RATE (%)
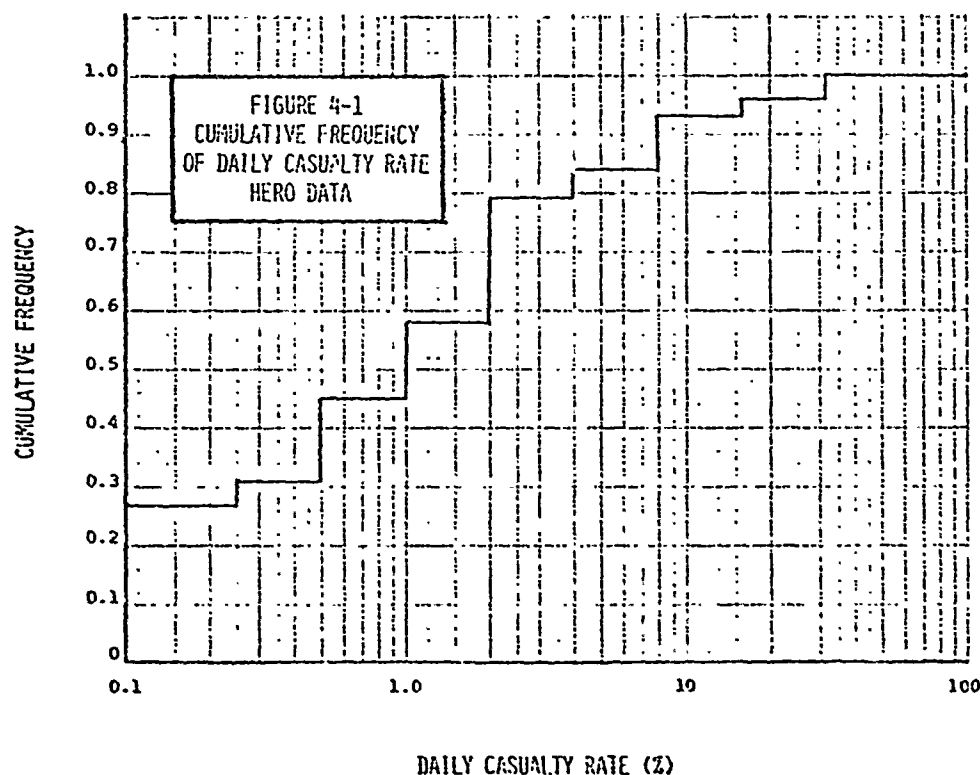
for casualty rate percentages to show the rough linear relationship of the logarithmic casualty rate to cumulative frequency. This suggests an exponential distribution. The casualty rate here reflects total combat casualty losses.

The Summers data indicate the casualty rate for each day for each of 78 rifle-company days in combat. In Figure 4-2 cumulative frequency is plotted against daily casualty rate (on a linear scale) based upon the 1943 Army rifle-company TO&E strength of 193 personnel. Once again, the casualty rate appears to follow an exponential distribution (casualties here refer only to WIA's).

FIGURE 4-2
CUMULATIVE FREQUENCY
OF DAILY CASUALTY RATE
SUMMERS DATA

DAILY CASUALTY RATE (%)
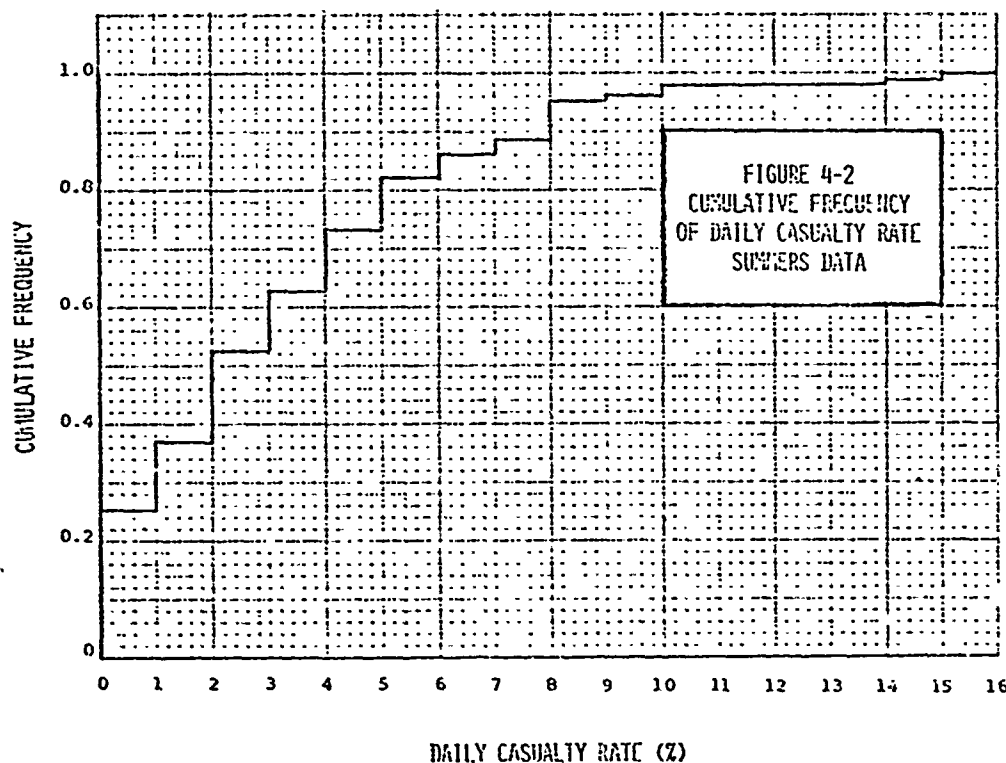
An unpublished analysis of Special Landing Force (SLF) operations in Vietnam from 1965 to 1968 by the Marine Corps Operations Analysis Group (MCOAG) is available at the Marine Corps Development and Education Command (MCDEC). That report contains numerous extracts of after-action reports which list,

inter alia, the number of days in contact with the enemy and the number of casualties incurred during the operation. This source is particularly attractive because it provides much more recent data on the Marine Corps, involving combat units of essentially the same composition conducting amphibious operations. Both the HERO and Summers data refer to WWII or Korean War operations; HERO aggregates data on non-homogeneous combat units at approximately division-level size. With this in mind, the SLF data were transformed in the same manner as the HERO and Summers data. Wherever possible, only evacuated WIA's and DNBI's were recorded.[1] The result of this transformation, to cumulative frequency of casualty rate in percent, is shown in Figure 4-3. Once again, the casualty rate appears to follow an exponential distribution.

FIGURE 4-3
CUMULATIVE FREQUENCY
OF DAILY CASUALTY RATE
SPECIAL LANDING FORCE DATA

DAILY CASUALTY RATE (%)

_____
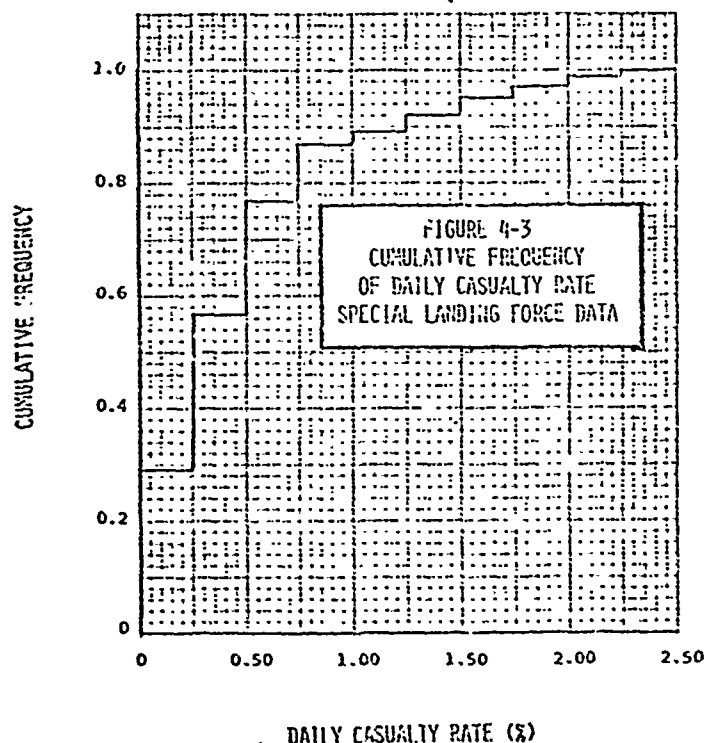
[1] Refinement of the resulting graph should include an attempt to differentiate between casualties requiring evacuation and casualties not requiring evacuation.

With three different references (the only ones which provided data amenable to the generation of these casualty rates) leading to the same general conclusion, it is reasonable to assume that casualty rates are exponentially distributed.

D. GENERATING A RANDOM DAILY CASUALTY RATE

Assuming exponential distribution of daily casualty rates, the procedure for generating a random daily casualty rate is as follows:

Let y represent the relative cumulative frequency of the daily casualty rate, x. Then:

$$y = 1 - e^{-\lambda x} \qquad x \geq 0 \qquad (1)$$

The mean value of this distribution is $1/\lambda$, which can be equated to empirically-estimated values for various combinations of combat unit strength and combat intensity. The most relevant source of information on those values is contained in the MCDEC Medical-Dental Study.[1] That study also sets forth explicit methods for adjusting casualty rates for combat elements in relation to parent command casualty rates. Those methods are recommended by LMI for use in converting from brigade level rates to battalion or company level rates.

The next step is straightforward. Since y is uniformly distributed on the unit interval, a sample value of y may be drawn from a uniform distribution. The sample daily casualty rate, x, then may be determined by solving equation (1) for λ, i.e.,

$$x = \frac{-\ln (1 - y)}{\lambda} , \qquad (2)$$

and then evaluating x at the selected value of y. A number of

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[1] loc. cit., Annex B.

methods are available for that evaluation, but a table of corresponding x and y values appears to be the most appropriate for the SMLS model. In that way, a randomly selected casualty rate can be made available for application to the combat day under consideration.

E.   <u>MONTE CARLO TECHNIQUE FOR GENERATING CASUALTY OCCURRENCES</u>

Determination of casualty occurrences over the 24 hours of the day is conceptually simple. This determination requires the selection of an appropriate probability density function[1] and a technique for generating random casualties based on the cumulative distribution of that density function. Assuming that the probability density function is known, discussion of the determination of random casualty occurrences follows. The purpose of the determination is to establish a means whereby the time of occurrence of each successive casualty may be randomly selected, such that the total number of casualties over the 24-hour period will be equivalent to the randomly selected daily casualty rate. For example, Figure 4-4

FIGURE 4-4

PROBABILITY DENSITY FUNCTION, $f(t)$

---
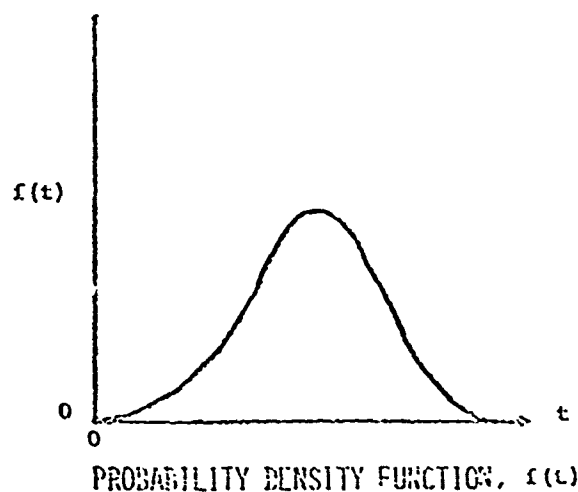
[1]Factors influencing this selection are discussed in Section F of this appendix.

illustrates a hypothetical casualty "density" function $f(t)$; the abscissa is time, t, scaled to represent that segment of a 24-hour day in which casualties may occur; the ordinate is the probability density of t suitably scaled so that the area under the curve is unity. This density function might represent a situation where combat is most intense at noon.

Figure 4-5 represents the cumulative distribution function, $F(t)$, that is, $F(t)=\int f(t)dt$, on the left ordinate. The right ordinate represents the successive occurrence of casualties over the selected time period, such that the total casualties incurred is equal to $[x']$; $[x']$ is equal to the total number of casualties for the day (rounded to the nearest integer) derived from the randomly chosen daily casualty rate x. The right ordinate is divided into integer intervals. The times, t_1, t_2, $\ldots$ $t_{[x']}$, are read off the abscissa. It now remains only to select an appropriate probability density function.

FIGURE 4-5
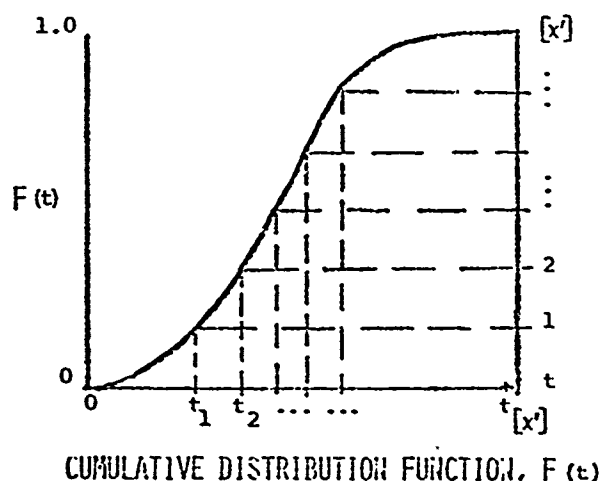
CUMULATIVE DISTRIBUTION FUNCTION, $F(t)$

F. FACTORS INFLUENCING THE SELECTION OF AN APPROPRIATE PROBABILITY DENSITY FUNCTION

There is no discussion of such a function in the literature investigated. The function depends on the scope and intensity of the combat operations to be simulated which can best be determined by the professional military experience of the user. It is emphasized that the selection of an appropriate distribution function is of critical importance in deriving peak load estimates. Therefore, all assumptions used to establish the distribution should be explicit.

The possibilities for such a distribution include uniform, normal, log normal, Poisson, etc. The shapes can be unimodal, bimodal, skewed, etc. Factors to consider in selecting a distribution suitable for SMLS purposes include:

- likelihood of night-time combat operations

- specific combat unit tactical doctrine and assigned mission

- presence or absence of periodic enemy sniper activity

- availability of reserve troops

- likelihood of more than one pitched battle per day

The impact of these factors is discussed below.

If night-time combat operations are considered unlikely, then the probability density function will be truncated at both ends of the t-axis. This would have the effect of compressing the combat period and decreasing the time intervals between successive casualties.

Assume for the moment that unit tactical doctrine and mission assignment called for substantial patrol activity in the morning and early afternoon, followed by perimeter defense in the evening and night-time. Under this assumption it reasonably could be expected that the density function would be skewed toward the origin with a relatively long flat tail to the right. The presence of periodic enemy sniper activity could be expected to impose a general flattening of density function peaks while raising the lower levels. If it were assumed that more than one pitched battle would occur on a given day, the resultant density function would be bimodal, or even multimodal.

The availability and use of reserve troops for reinforcement during a combat scenario adds some complicating factors, such as time-dependence of casualty occurrence between the reinforced and the reinforcing units. It seems reasonable to assume that the reinforced unit's incremental casualty rate would be reduced starting with the arrival time of the reinforcing unit, which should then begin experiencing occurrence of casualties. Nonetheless, the total casualty rate for the combined strength of both units must realistically remain in the neighborhood of the empirically-estimated mean value, if this procedure is to have meaning. Hence, it is essential to recognize the dependence of casualty rates between cooperating units.

As mentioned earlier, the identification of peaks in the density function is critical to the validity of the simulation. Since $f(t)=dF(t)/dt$ in Figures 4-4 and 4-5, the higher the peak of $f(t)$ the steeper the slope of $F(t)$. As $F(t)$ becomes steeper, the intervals between the t_i become smaller, implying a more rapid occurrence of casualties. This raises the number

of casualty load units per unit of time. It is conceivable that discrete probability density functions could be used, resulting in a cumulative distribution function with discrete steps. This would provide a more realistic generator in that multiple casualties might occur simultaneously.

G.   SUMMARY

The following conclusions pertinent to the data requirements unique to the medical subsystem have been reached:

- Estimators of fractions of total casualties requiring evacuation, as found in the literature, should be viewed with caution. After-action reports of recent combat involving elements comparable in size and mission to those in SMLS should be consulted for these data.

- Daily casualty rates suitable for the SMLS concept are exponentially distributed.

- Despite the absence of data, a means to simulate the realistic occurrence of casualties throughout a day can be achieved.

- Assumptions made about tactical doctrine and battlefield environment are critical factors influencing the choice of a suitable daily probability distribution for the SMLS simulation model. The assumptions must be tempered by military judgment and experience.

APPENDIX 5

LIST OF SMLS EQUIPMENTS FOR W   H

SELECTED MAINTENANCE DATA ARE AVAILABLE

APPENDIX 5

LIST OF SMLS EQUIPMENTS FOR WHICH

SELECTED MAINTENANCE DATA ARE AVAILABLE

Federal Stock Number	Nomenclature
2320-763-1092	Truck, Utility, 1/4 T, M-151A1
2310-782-6056	Truck, Ambulance, 1/4 T, 4x4, M718
2320-074-1167	Truck, Platform, 1/2 T, 4x4, M274A2
2320-542-4632	Truck, Cargo, 3/4 T, 4x4, M37B1
2330-055-9262	Truck, Dump, 5 T, 6x6, M51A2
2320-055-9258	Truck, Wrecker, 5 T, 6x6, M543A2
2320-077-1632	Truck, Tank, Fuel, M49A2C
2320-055-9260	Truck, Tractor, 5 T, M52A2
2350-895-9154	Truck, Combat, Full-Tracked, M48A3